Oct. 11, 1960 M. G. COMUNTZIS 2,955,470

MAGNETIC-CONTACT ACCELEROMETER

Filed Feb. 19, 1959 3 Sheets-Sheet 1

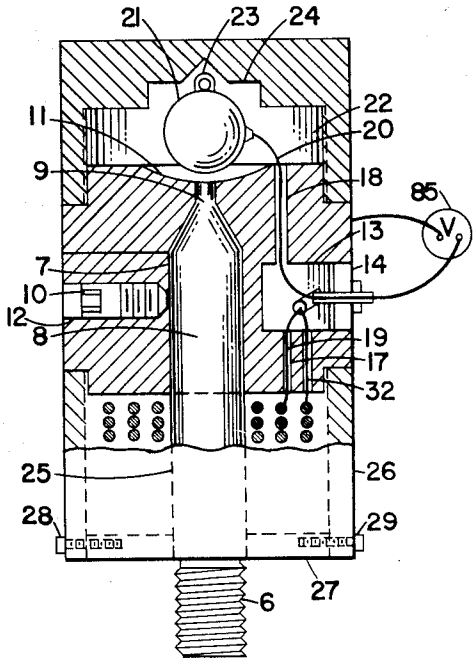


FIG. 2

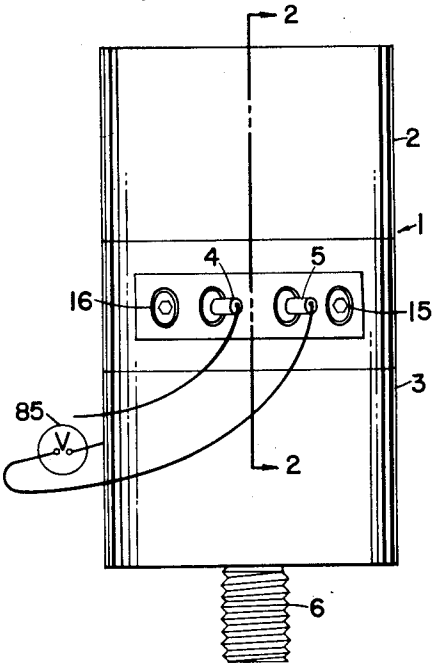


FIG. 1

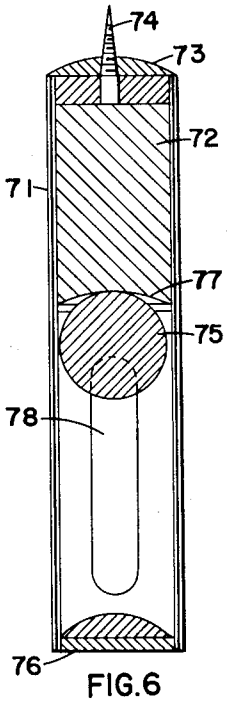


FIG. 6

Marcus G. Comuntzis,
INVENTOR.
BY J. J. Rotondi,
A. T. Dupont,
H. M. Snyder, and
Alvin E. Moore,
ATTORNEYS.

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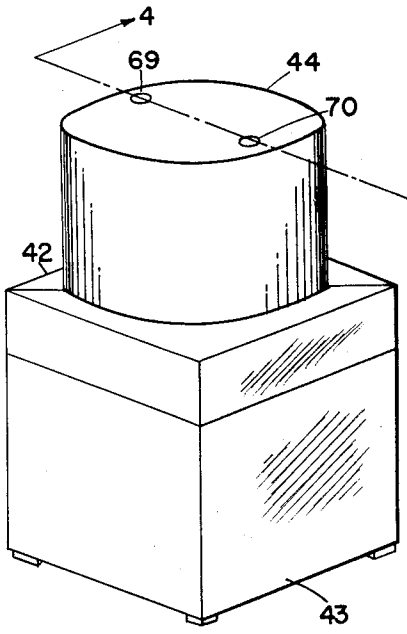


FIG. 3.

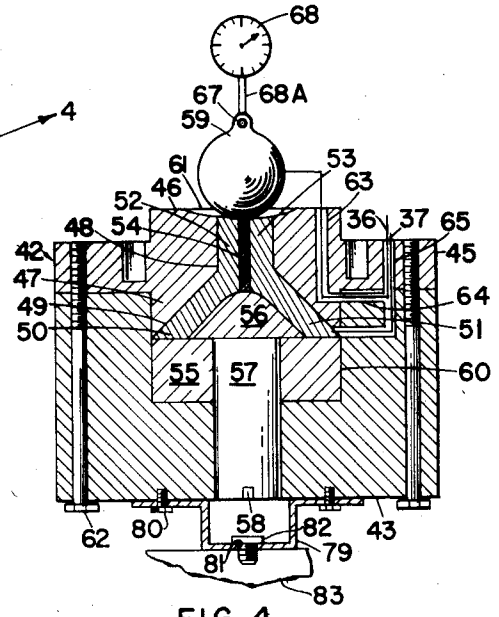


FIG. 4

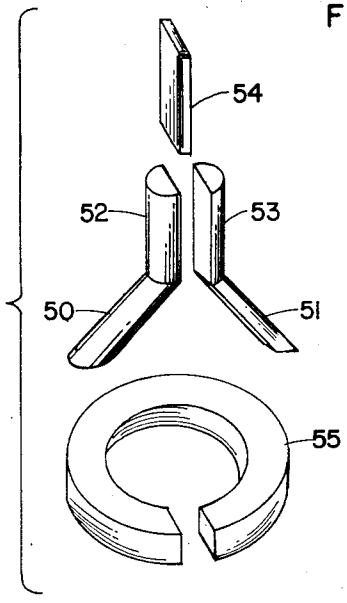


FIG. 5.

Marcus G. Comuntzis,
INVENTOR.
BY S. J. Rotondi,
A. T. Dupont,
H. M. Snyder, and
Alvin E. Moore,
ATTORNEYS.

Oct. 11, 1960 M. G. COMUNTZIS 2,955,470

MAGNETIC-CONTACT ACCELEROMETER

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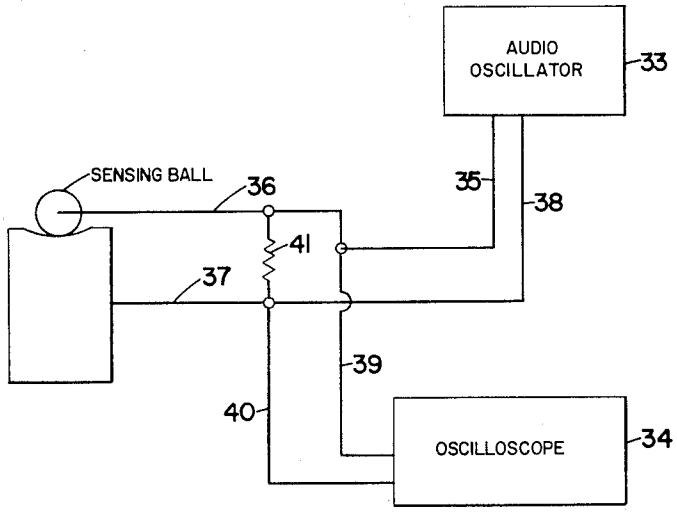


FIG. 7

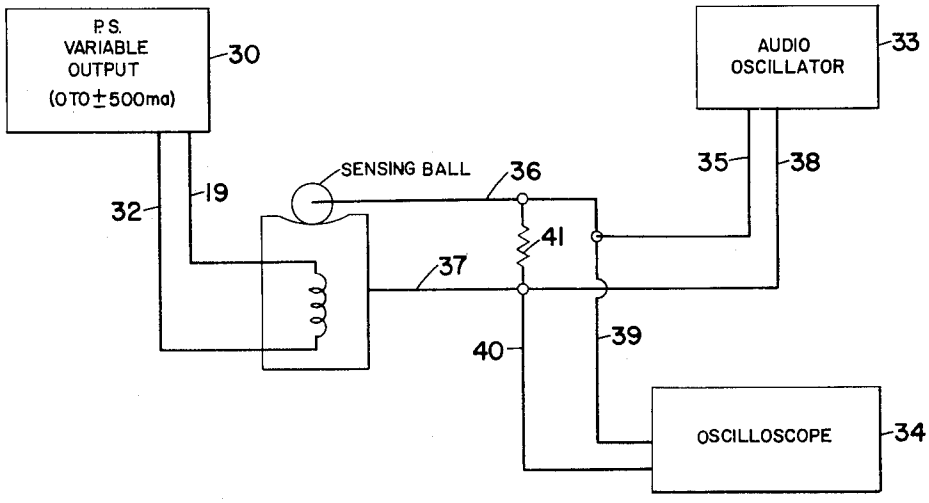


FIG. 8

Marcus G. Comuntzis,
INVENTOR.
S. J. Rotondi,
BY A. T. Dupont,
H. M. Snyder, and
Alvin E. Moore,
ATTORNEYS.

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MAGNETIC-CONTACT ACCELEROMETER

Marcus G. Comuntzis, Pasadena, Calif., assignor to the United States of America as represented by the Secretary of the Army

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2 Claims. (Cl. 73—492)

This invention relates to a magnetic-contact accelerometer. Such an accelerometer, of the chatter type, provides means for determining levels of acceleration, shock and vibration on components tested in the laboratory.

When missiles, aircraft, or machine elements are subjected to peaks of acceleration, shock or vibration in laboratory testing, there is a need for such a chatter type accelerometer that will measure peaks of acceleration in excess of one *g*. There are further needs for an accelerometer, which does not depend on springs in its operation and for an accelerometer that will measure various ranges of acceleration.

In view of these facts, an object of this invention is to provide a chatter accelerometer which will operate at levels above one *g*.

Another object of the invention is to eliminate the springs normally required in chatter accelerometers.

A further object is to provide an accelerometer which has means whereby the range of the accelerometer can be varied.

The foregoing and other objects of this invention will become more fully apparent from the following detailed description and from the accompanying drawings, in which:

Figure 1 is an elevational view of the electromagnetic accelerometer.

Figure 2 is a view that is partially in section, taken along the line **2—2** of Figure 1.

Figure 3 is a perspective view of an embodiment, comprising a permanent magnet.

Figure 4 is a sectional view taken along line **4—4** of Figure 3, but showing the cap removed and a calibration device in use.

Figure 5 is an exploded view of the two pole pieces, nonmagnetic metal piece and the magnet shown in Figure 4.

Figure 6 is a sectional view of another embodiment comprising a permanent magnet.

Figure 7 shows a preferred circuit for use with the permanent magnet accelerometer of Figures 3 to 5.

Figure 8 shows a preferred circuit for use with the electromagnetic accelerometer.

In the drawings, wherein for the purpose of illustration there are shown three embodiments of the invention and particularly in Figures 1 and 2, a generally cylindrical accelerometer is comprised of a nonmagnetic body member **1**, which may be of plastic or nonmagnetic metal such as aluminum, a nonmagnetic cap **2**, a flux-density coil assembly **3**, a power connection **4**, a meter connection **5**, and mounting means **6**. The accelerometer more specifically comprises a central bore **7**, an electromagnet armature **8**, terminating in a pole piece **9**, adapted to be fitted in the bore **7**, a set screw **10**, adapted to fit screwthreaded opening **12**, for holding the armature **8** in place and a recess **11** in the end of the body **1** confronting the cap **2**.

The mid-section of body member **1** contains a niche **13** for receiving a crescent like connecting bracket **14**, which

is secured to body **1** by screws **15** and **16**. The power and meter connections **4** and **5** are attached to this bracket.

A pair of apertures **17** and **18** are open to niche **13** at one of each of the apertures' ends. The other end of aperture **17** terminates at coil assembly **3**; and the other end of **18** terminates at the edge of parti-spherical recess **11**. These apertures serve as passageways for power lead **19** from connector **4** to coil **3**, and for meter lead **20** from the meter connection **5** to a magnetic metal ball **21**, located in chamber **22**.

The ball **21** is freely mounted within the limitations of chamber **22**. The chamber **22** is formed between cap **2** and the upper end of body **1** when the cap **2** is in position on the body **1**, that is after the instrument has been calibrated and is in use. The ball **21** has a flattened surface, which contains an upwardly disposed calibration eyelet **23**. Eyelet **23** is adapted to receive a hook or other connector **68A** of a force measuring means **68**, for calibration purposes, as indicated in connection with a second embodiment, shown in Figure 4.

A second recess **24** is formed in cap **2** and confronts recess **11**. Recess **24** serves as a keeper and guide means for retaining the loosely fitted ball **21** in position on top of the pole piece **9**.

The end of armature **8**, opposite from pole piece **9**, passes thru an opening **25** in the coil of coil assembly **3**, and terminates in a screw-threaded mounting means **6**.

The coil assembly **3** comprises a nonmagnetic sleeve **26** and an end plate **27**. The end plate is press-fitted on armature **8**, and is secured to sleeve **26** by screws **28** and **29**. The coil assembly is then secured to body **1** by the action of set screw **10** on armature **8**.

The form of the invention in Figures 1 and 2 is shown as comprising a voltmeter **85**, which enables the operator to ascertain when the accelerometer has been subjected to a predetermined level of acceleration. At this time, ball **21** leaves its seat **11** and breaks the circuit containing voltmeter **85**, whereupon the voltmeter ceases to register voltage, indicating that said level has been reached. The predetermined level may be adjusted by varying the current supplied from power supply **30** to the coil of the electromagnet.

The circuit shown in Figure 8 may be utilized with this electromagnetic form of the accelerometer in lieu of the voltmeter circuit. In Figure 8, as in Figure 2, variable output power supply **30** is connected with the electromagnet by conductors **19** and **32**, and the indicating means is connected via conductors to the casing of the instrument and to the ball. In Figure 8 the indicating means is shown as comprising an audio oscillator **33** and an oscilloscope **34**, connected in parallel. Audio oscillator **33** receives current from an electrical source as indicated in Figure 8 and supplies alternating voltage to a circuit comprising conductors **35**, **36**, **37** and **38**. This circuit has less resistance than the parallel circuit containing the oscilloscope. When acceleration-caused movement of ball **21** breaks the circuit thru the ball, voltage from **33** goes thru conductors **39** and **40** and the oscilloscope, thus indicating that a predetermined level of acceleration has been reached. At this time voltage does not short-circuit thru resistor **41**, due to the fact that said resistor has more resistance than the oscilloscope.

The operation of the form of the devices shown in Figures 1, 2 and 8 is as follows:

The accelerometer is mounted on the element to be tested and power to the coil adjusted to the desired amount.

A force measuring means, shown in Figure 4, is then connected to the calibration eyelet **23**, and the force necessary to separate the ball **21** from the magnet is measured.

The acceleration necessary for the separation of the

ball from the magnet is then calculated by dividing the separation force by the mass of the ball **21**.

This procedure would be carried out various times for various given amounts of amperage supplied by the power source, and from the resulting data a calibration chart may be made, showing the different accelerations obtainable with different power ratings.

When the calibration is obtained from a chart or directly from testing, as described above, and the voltmeter or, alternatively, the circuit shown in Figure 8, is connected to the ball and casing and the coil, the element is ready to be tested.

If the circuit of Figure 8 is being utilized, the oscillator is turned on, so as to send a signal thru the ball. When the ball is in place this signal will be shorted back to the oscillator, but when the tested element is subjected to the calibrated acceleration the ball will be unseated and the short circuit opened, and the signal is supplied to the oscilloscope, due to the resistor **41**, so as to indicate on the oscilloscope that the calibrated acceleration has been reached.

The acceleration value then can be changed as described above and the element subjected to a different acceleration value.

In the embodiment shown in Figures 3 to 5, a permanent magnet is used in the accelerometer.

In this embodiment the exterior of the accelerometer comprises a nonmagnetic body **42**, a square, nonmagnetic metal base **43** and a nonmagnetic cap **44**.

The body **42** is comprised of a substantially square metal piece **45**, partially conforming to the shape of the top of base **43**. This piece has a pair of generally cylindrical portions **46** and **47**, one being located above and the other below said substantially square metal piece.

The upper portion **46** has an internal bore **48**, and lower portion **47** has an internal conical surface **49** which joins bore **48**.

Within and against conical surface **49** there are located two legs of magnet pole pieces **50** and **51**, which join at their upper parts in integral, parti-annular magnetic elements **52** and **53** which fit within bore **48**. Said elements or upper pole piece portions are separated by nonmagnetic metal piece **54**. Magnetic elements **50** to **53** thus form two pole pieces which rest on permanent magnet **55**, which is rotatably mounted in bore **60** in the top of base **43**. Nonmagnetic filler piece **56** optionally fills the space between nonmagnetic metal piece **54** and the top of rotatable nonmagnetic rod **57**, which is press-fitted in magnet **55**. This rod may be turned by means of a screwdriver fitted in kerf **58**, so as to vary the intensity of the magnetic force transmitted thru the pole pieces to ball **59** which is seated in recess **61**. The magnetic force from magnet **55** is caused to take an indirect path from one of the pole pieces to the other, via ball **59**, because of the nonmagnetic element **54**.

Base **43** is secured to body **42** by a plurality of mounting studs **62**.

A conductor **36** has one end connected to ball **59**. The other end is passed thru bores **63**, **64** and **65** to an exterior indicator circuit.

Ball **59** has a calibration eyelet **67** for receiving hook **68**A of force measuring device **68**.

Cap **44** is fitted over cylindrical portion **46** enclosing conductor **36** and ball **59**. This cap is secured in position over portion **46** by screws **69** and **70**.

The circuit used in this embodiment is the same as the circuit of Figure 8, used in the embodiment shown in Figures 1 and 2, except that power supply **30** is eliminated and conductor **37** is connected to pole piece **51**. Therefore, components common to Figures 7 and 8 are indicated by the same reference numerals.

The operation of this embodiment is as follows:

Rod **57** is turned until magnet **55** is rotated to a desired position. The remainder of the operation, for obtaining the ball-separating acceleration, is the same as in the operation for Figures 1, 2 and 8.

The results obtained from various rotary positions of rotary rod **57** may be indicated by a single mark on the base of the rod, which in rotating registers with one of various marks on fixed base **43**, near rod **57**. This would enable the user to dial the acceleration desired by lining up the marks corresponding to the acceleration.

In Figure 4, a second form of accelerometer mounting means is shown. Bracket **79** is fastened to base **43** by means of screws **80**, and may be attached to the element **82** to be tested under accelerations by bolts **83** extending thru hole **81**. This bracket is open on two of its sides, so that a tool may be inserted for adjustment of the magnet without the necessity of removing the bracket from base **43** or from said element.

The embodiment shown in Figure 6 illustrates a type of accelerometer that comprises a permanent magnet and means on the accelerometer for observing the action of the magnetic ball.

In this embodiment the numeral **71** indicates a nonmagnetic metal cylinder having a permanent cylindrical bar magnet **72** that is secured in the cylinder by end plate **73** that is press-fitted or otherwise fixed to the cylinder. Mounting means **74** may be screwed into the base or another part of the element to be tested. A magnetic metal ball **75** is located in one end of cylinder **71**, supported for substantially free movement and adapted to fit a recess **77** formed in the end of the magnet opposite from plate **73**. A pair of oblong observation slots **78** are located in the wall of said end of the cylinder. A second end plate **76** is press-fitted or otherwise fixed to said end of the cylinder.

In the use of this embodiment it is necessary to choose an accelerometer that has a mass of the ball and a magnet adapted to fit the desired acceleration.

The chosen accelerometer would be good for one acceleration value and if a different acceleration is desired an accelerometer designed for the different acceleration must be used. Alternatively, using only one basic accelerometer, the mass of the ball and/or the magnetic force could be varied by substitution of different balls and/or magnets.

The operation of this embodiment is as follows:

When the acceleration for the test is determined an accelerometer having a magnet and ball of the necessary characteristics is selected. This accelerometer is connected to the member to be tested and is subjected to acceleration.

When the member reaches the predetermined acceleration, the ball separates from the magnet. This separation will be indicated by the movement of the ball relative to the observation slots.

This form of invention may be utilized to indicate various accelerations by the provision of gradation marks on cylinder **71** adjacent slots **78**, each mark indicating the extent of travel of the ball (against magnetic force) for a given acceleration.

It is to be understood that the forms of the invention that are herein shown and described are preferred embodiments, and that various changes in the shape, size and arrangement of parts may be resorted to without departing from the spirit of the invention, or the scope of the subjoined claims.

The following invention is claimed:

1. An accelerometer comprising: a nonmagnetic housing having an axis; a nonmagnetic detachable cap secured to said housing, providing a substantial space between the central part of said cap and said housing; screwthreaded means for mounting said housing on an element to be tested; a ball of magnetic material supported in said housing in said space, having a diameter shorter than the extent of said space along said axis, for limited relative movement in said space under acceleration of said element; a magnet within said housing ad-

jacent said ball, for exerting magnetic force on said ball in opposition to said accelerations; two pole pieces of magnetic material mounted in said housing, each extending from a point closely adjacent said magnet to a point adjacent said ball, said pole pieces having a space between them; a nonmagnetic rod fixed within said magnet and having a kerf at one of its ends for coaction with a screw driver for rotating said magnet and its poles relative to said pole pieces; a seat for said ball, said seat being within said housing and having a recess of varying depth with the point of greatest depth being at said axis, said ball being drawn by said magnetic force toward said point; and means to indicate when said ball leaves said seat under the influence of said acceleration.

2. A device as set forth in claim 1, in which said magnet is mounted in said housing at a constant distance in all positions of its rotation by said rod.

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